MINING METHODS AND COSTS AT THE WESTSIDE MINE OF THE EAGLE-PICHER CO. CHEROKEE COUNTY, KANS.

BY S. S. CLARKE

* * * * * * * * * **Information Circular 7774**

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INTRODUCTION

This paper on methods and costs of mining at the Westside mine, in the Tri-State zinc- and lead-mining district (Missouri-Kansas-Oklahoma), is one of a series being prepared by the Bureau of Mines on mining practices, methods, and costs in various mining districts of the United States.

Methods and equipment used in drilling, loading, and underground transportation have changed radically since the latest Bureau of Mines publications[2] on mining methods in the district were published more than 20 years ago. More efficient methods and machines have been developed in order to maintain low operating costs in the face of rising labor and supply costs and lower grade ore. The rate of conversion to mine mechanization was disappointing at times; local conditions required the development of special equipment, and available rock-moving machines had to be remodeled and strengthened.

The Westside mine, one of a group operated by The Eagle-Picher Co. in the district, is in the SW1/2 sec. 7, T. 35 S., R. 24 E., sixth principal meridian, Cherokee County, Kans., about 1-1/2 miles north of Picher, Okla. (fig. 1). The mine is in the northern part of the Oklahoma-Kansas field, which constitutes the southwest and most productive part of the Tri-State district.

ACKNOWLEDGMENTS

Acknowledgment is made to The Eagle-Picher Co. for permission to publish this paper. Special acknowledgment is due to Carl Williams, division superintendent; Ben Moody, statistician; and Frank Charlton, mine foreman, for their cooperation and assistance in compiling operational and cost data.

The assistance of Burton M. Reynolds, mining engineer, Federal Bureau of Mines, in preparing this paper is also greatly appreciated.

HISTORY

Metal mining began in the Tri-State zinc-lead district about 1848, but until 1918 the major part of the annual output of zinc and lead concentrates was produced in the eastern part of the district, which included southwest Missouri and a small area in and near Galena, Kans.

2/ Jackson, Chas. F., Knaebel, John B., and Wright, C. A., Lead and Zinc Mining and Milling in the United States; Current Practices and Costs: Bureau of Mines Bull. 381, 1935, 204 pp.

3/ Anderson, C. N., Mining Methods and Costs at the Interstate Zinc and Lead Co's Hartley Mine, Tri-State Zinc and Lead District: Bureau of Mines Inf. Circ. 6656, 1932, 16 pp.

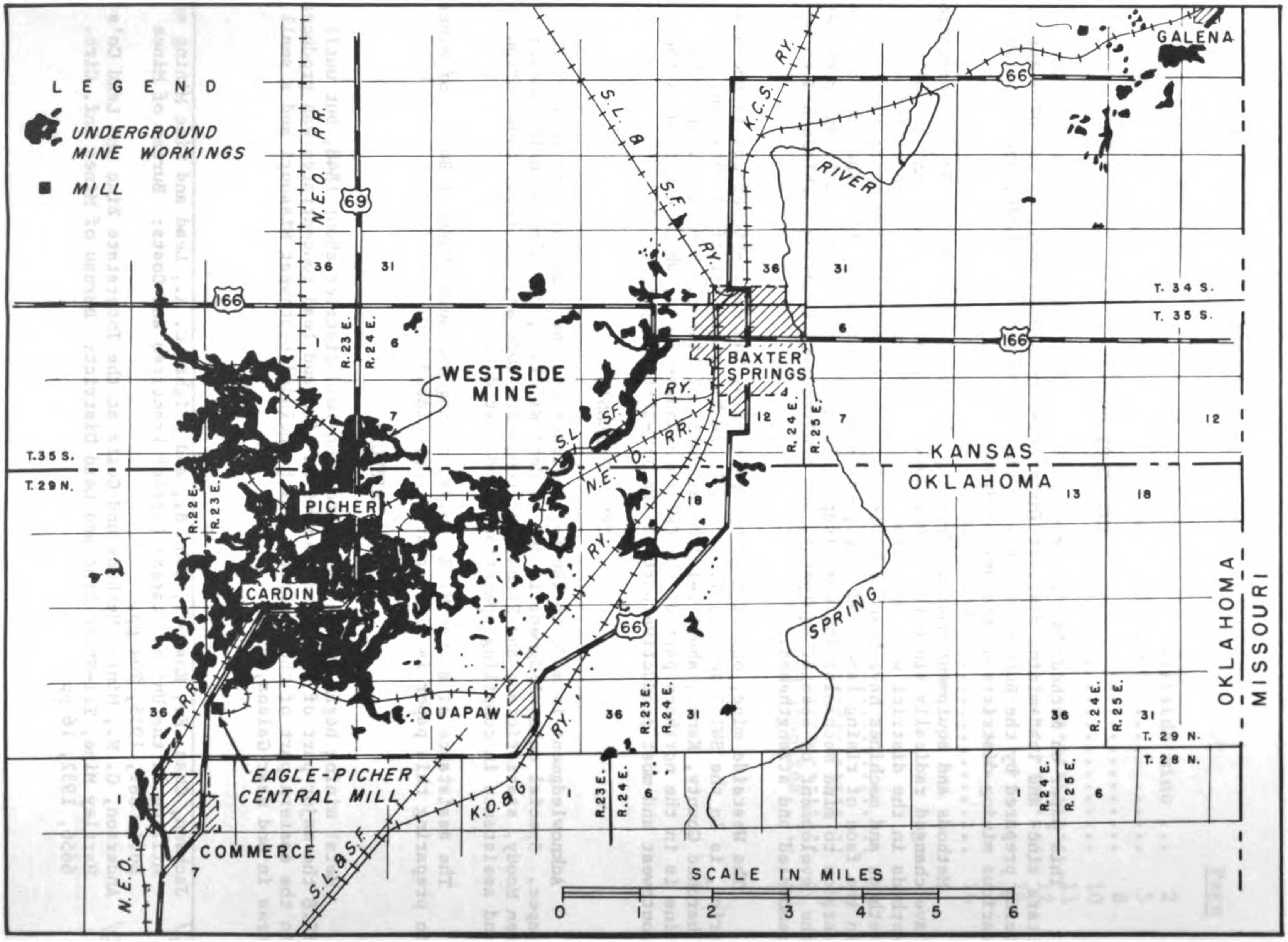

Figure 1. - Oklahoma-Kansas field, showing location of Westside mine.

Zinc and lead ores were discovered in northeast Oklahoma near Peoria, Lincolnville, and the present town of Commerce in the 1890's and early 1900's. The first of the large ore bodies in the main Picher or Oklahoma-Kansas field was discovered by wildcat drilling in 1914. This discovery and the greatly increased demand for zinc and lead during World War I provided the impetus for rapid expansion of exploration, development, and mill construction in the Oklahoma-Kansas field. Beginning in 1918, annual production from this field far exceeded that in the eastern part of the district, where many of the mills were closed, and later moved to newly developed mines in the vicinity of Picher, Okla.

Production in the Tri-State district reached its peak in 1926, when the output was 956,319 short tons of zinc and lead concentrates containing 423,800 tons of recoverable zinc and 102,117 tons of lead.3/ Over 90 percent of the concentrates (868,499 tons) was produced in the Oklahoma-Kansas field. The trend in production has been downward for the past 25 years, except for the early part of World War II. The average annual output during 1948-54 was about 177,000 tons of concentrates - a drop of nearly 75 percent from the average for 1917-29. The total recorded production in the district to the end of 1954 was 22,204,500 short tons of zinc concentrates and 3,626,900 short tons of lead concentrates with a combined value of $1.3 billion. The Oklahoma-Kansas field produced 60 percent of the district's total output.

Zinc-lead ore was discovered in the SW1/4 sec. 7 (Westside tract) in 1915, a time when many other major ore discoveries were being made in the vicinity of Picher. The Barr mine4/ was opened shortly thereafter in the southwest part of the tract by Vinegar Hill Zinc Co. and was worked by that company for many years. The ore body north and east of the Barr was developed by Commerce Mining & Royalty Co. and was worked as the Westside mine.

The Westside and other properties were acquired by The Eagle-Picher Co. in 1938 from Commerce Mining & Royalty Co. Vinegar Hill Zinc Co. sold the Barr mine in April 1940 to Jane E. Mining Co., which, after a short period of operation, sold it to The Eagle-Picher Co. The mine then became a part of the Westside group.

Production from the properties comprising the present Westside mine has totaled 8,395,660 tons of ore, from which 503,734 short tons of zinc concentrates and 80,818 short tons of lead concentrates were recovered.

Most of the mines in the Tri-State district were in leaseholds. It was established practice for many years, owing to demands by property owners and the Federal Government in behalf of its Indian wards in Oklahoma, to build a separate mill on each property - commonly one on each 40-acre tract. These restrictions were not conducive to conservation of the district's metal resources. In time the mines on small tracts could not produce enough ore to warrant continuous mill operations because recoveries in small mills were low, and mining was limited of necessity to the higher grade ores. In the early 1930's The Eagle-Picher Co., realizing that many of the mines would soon be forced to close and leave large tonnages of low-grade ore that could be mined under more favorable conditions, conceived the idea of building

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3/ Martin, A. J., Summarized Statistics of Production of Lead and Zinc in the Tri-State (Missouri-Kansas-Oklahoma) Mining District: Bureau of Mines Inf. Circ. 7383, 1946, 67 pp.

4/ Keener, Oliver W., Method and Cost of Mining at Barr Mine, Tri-State Zinc and Lead District: Bureau of Mines Inf. Circ. 6159, 1929, 9 pp.

a large central mill with accurate weighing and sampling controls. The Government approved the plan, which would safeguard the interests of the Indian landholders, and the Central mill was built in 1932 (fig. 1). Mill capacity is now 15,000 tons per day.

Eventually, some of the mines were unable to continue producing enough ore to pay for maintaining separate hoisting facilities. Inasmuch as the ore remaining in adjoining mines was nearly uniform in grade, permission was obtained to commingle the ores from several leases and hoist them at the most convenient shaft.

Centralization of hoisting and milling operations has lengthened the productive life of the Oklahoma-Kansas field and will permit much higher extraction of the ores than otherwise would have been possible.

DESCRIPTION OF DEPOSITS

The zinc-lead ore deposits of the Tri-State district occur mainly in the Mississippian Boone formation, which comprises beds of limestone, dolomite, and massive chert, one or more oolite beds, and numerous chert-nodule beds. These beds, believed to have been deposited as nearly pure limestone, were progressively deformed and shattered by regional deformation, then replaced in sequence by chert, dolomite, jasperoid, lead and zinc sulfides, and other minerals.

Fowler and Lyden[5/] classified the Boone formation into a series of individually lettered beds, from B to R (except I) in descending order and noted the characteristics that made them favorable or unfavorable to ore deposition (fig. 2). Favorable reservoirs for ore were: (1) Porous formations that could be replaced; (2) cavernous horizons; (3) shattered or brecciated areas or open fissures; and (4) any combination of these. Horizons of shattering accounted for most of the ore deposits, and nearly all of the ore found in the district occurred in six of the lettered beds of the Boone formation. The upper ore-bearing beds in the Oklahoma-Kansas field are covered by 100 to 200 feet of shale, sandstone, and limestone.

The M bed, one of the most important beds in the Oklahoma-Kansas field, has been the principal ore-producing bed in the Westside mine. The ore in the overlying G and H beds was lower in grade and could not be mined economically in the past. Owing to a more favorable price-cost ratio, made possible largely by mine mechanization, the ore in these beds is now of commercial grade and was the source of most of the mine production in 1954. The rock between the H and M beds was sparsely mineralized but, being thin, was mined with the overlying ore.

The ore minerals are sphalerite and galena, the sulfides of zinc and lead. The ratio of zinc to lead in the ores has varied widely throughout the district but has averaged about 4 to 1. The tenor of ore mined in the Oklahoma-Kansas field, in terms of recovery of combined zinc and lead concentrates, averaged 7.12 percent during 1918-24. Depletion of the higher grade ores, combined with the ability to mine lower grade ores economically, has resulted in a notable decrease in the average tenor - to 3.59 percent in 1950-54.

[5/] Fowler, George M. and Lyden, Joseph P., The Ore Deposits of the Tri-State District: Trans. AIME., vol. 102, 1932, pp. 206-251.

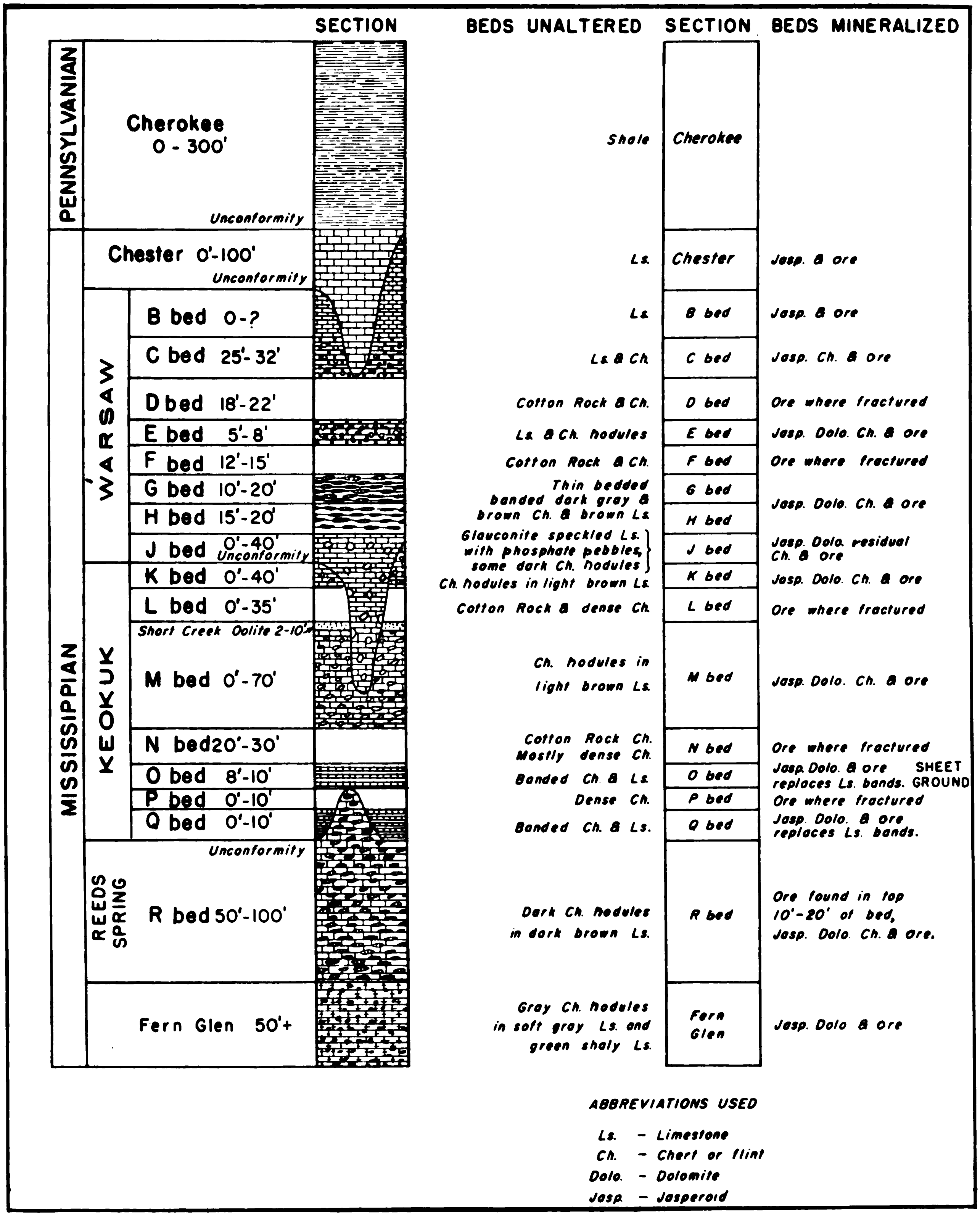

Figure 2. - Geologic section, Tri-State lead-zinc district.
(Courtesy, The Eagle-Picher Co.)

PROSPECTING AND EXPLORATION

The earliest prospecting in the Tri-State district was done by sinking shallow shafts, but churn drilling soon became the accepted method of probing for the deeper, hidden ore bodies. Core drilling was unsatisfactory because of low core recovery from the brecciated, creviced rock in and around the ore bodies and because of the difficulty in drilling through hard, abrasive chert and jasperoid.

Prospecting for ore in undeveloped areas was usually done by drilling widely spaced holes to determine the stratigraphy and presence or absence of ore minerals and to obtain other pertinent data. In outlying areas it was common practice to drill shallow holes at regular intervals in each tract to determine the configuration of the top of the limestone and thus locate sinks that might overlie an ore body.

Discovery of favorable structure or ore was followed by close drilling to explore the structure or the ore deposit, if one was indicated. Careful geological studies were made of the drill cuttings to detect the presence of ore minerals, dolomite or jasperoid, which might indicate the existence of ore in the drill hole or nearby. If visual observation of the cuttings indicated that they were of ore grade, samples representing measured intervals were assayed for zinc and lead. Following many years of practice, assays were commonly reported in terms of sulfides owing to the fact that the end products of mining and milling were zinc and lead sulfide concentrates.

Longhole drilling in the roofs and walls has been successful at some of the mines in exploring for ore above and adjacent to the mine workings. Drill cuttings were examined and logged in the same manner as those from churn drilling.

In the search for cheaper methods of prospecting in undeveloped areas, several geophysical methods have been tested with varying success in comparatively recent years. It has been demonstrated that electrical-resistivity methods can be used to map structures reflected by variations in the elevation of the buried limestone surface. Although it has not been found possible to determine by resistivity measurements the presence of ore minerals, it is possible to use the measurements in mapping certain structural and lithological features associated at many places with ore mineralization.6/

DEVELOPMENT

Early Development

Churn drilling was an essential part of the development of newly discovered ore bodies. Data obtained from development drilling largely determined the location of the main hoisting shaft, field shafts, and the mill and were used in planning mine layouts, including depths of mining levels and, in many instances, the location of pillars. Churn drilling was used also in connection with mine development to explore for extensions of known ore runs and to find isolated runs in the vicinity of but not connected to the main ore bodies.

6/ Jakosky, J. J., Dreyer, R. M., and Wilson, C. H., Geophysical Investigations in the Tri-State Zinc- and Lead-Mining District: Joint pub. of State Geol. Survey of Kansas (Bull. 44) and Engineering Experiment Station (Bull. 24), December 1942, 151 pp.

Once the shafts had been sunk to the ore, most of the underground development was an integral part of the mining operation. Development headings were driven in ore, and the main problem was to turn the pillars in the leaner ore wherever possible and still provide adequate support for the roof.

Virtually the only underground development work performed in barren or sparsely mineralized ground was the driving of occasional drifts or crosscuts to connect two separate ore bodies or to facilitate haulage between ore faces and the hoisting shaft. These drifts usually ranged from 7 by 7 to 8 by 10 feet in cross-section and seldom required timber support.

Present Development

Development and haulage drifts in mines of The Eagle-Picher Co. are now driven 12 feet high and 14 feet wide to give ample clearance for passage of equipment. The drilling pattern in drifts of this size varies to some extent in different mines and at different horizons, but the variation is usually limited to the number of relief holes and the angles at which the holes are drilled. The drift round used at the Westside mine consists of 19 to 22 holes drilled to a depth of 10 feet (fig. 3). The 3-hole burn cut is virtually standard, but occasionally a 5-hole burn cut is used.

The Eagle-Picher standard crawler-type drilling jumbo is used in drifting. It has a 12-foot boom that carries two 3-1/2-inch drifters mounted on 10-foot chain-fed sashes. The holes are drilled with 2-5/8-inch detachable steel bits or 2-3/8-inch carbide-insert bits.

Five to seven 50-pound boxes of explosive (40-percent strength) are used to load each round. A rigid safety rule requires that all primers be placed in cardboard safety shells. The average advance of the drifts is 9 feet per shift, and each round breaks 130 to 140 tons of rock. Fragmentation is good.

A drift crew consists of two men who drill and blast the rounds and load the broken rock for disposal. Drilling begins at noon and is usually completed in about 2-1/2 hours. The round is loaded and fired at the end of the shift. Broken rock is "mucked out" by the crew the following morning with a "Cat-mounted" slusher hoist. Waste rock is loaded into a diesel-powered dump truck and wasted in nearby abandoned headings thereby necessitating only short hauls. The drift is cleaned by noon when a new cycle of operations begins.

MINING METHODS

Early Mining

The open-stope (room-and-pillar) method of mining was adopted throughout the Tri-State district in the early days and still is the accepted method. Before crawler-type jumbos were developed, it was impracticable to drill and blast the full thickness of ore in one operation, except in the thinner ore bodies; hence the stopes were usually advanced in multiple steps. The first step was to drive a heading about 7 feet high at the top of the ore. The face of the heading was commonly kept about 15 feet ahead of the rest of the stope. The lower part of the stope, the face of which was sloping rather than vertical, was advanced by drilling and blasting long, flat stope holes at the bottom of the ore. Intermediate rows of "splitter" holes were drilled between the bottom stope holes and the heading, as required. After the stope holes were blasted, part of the broken ore was removed and part was left at the face to provide a base for drilling the splitter holes.

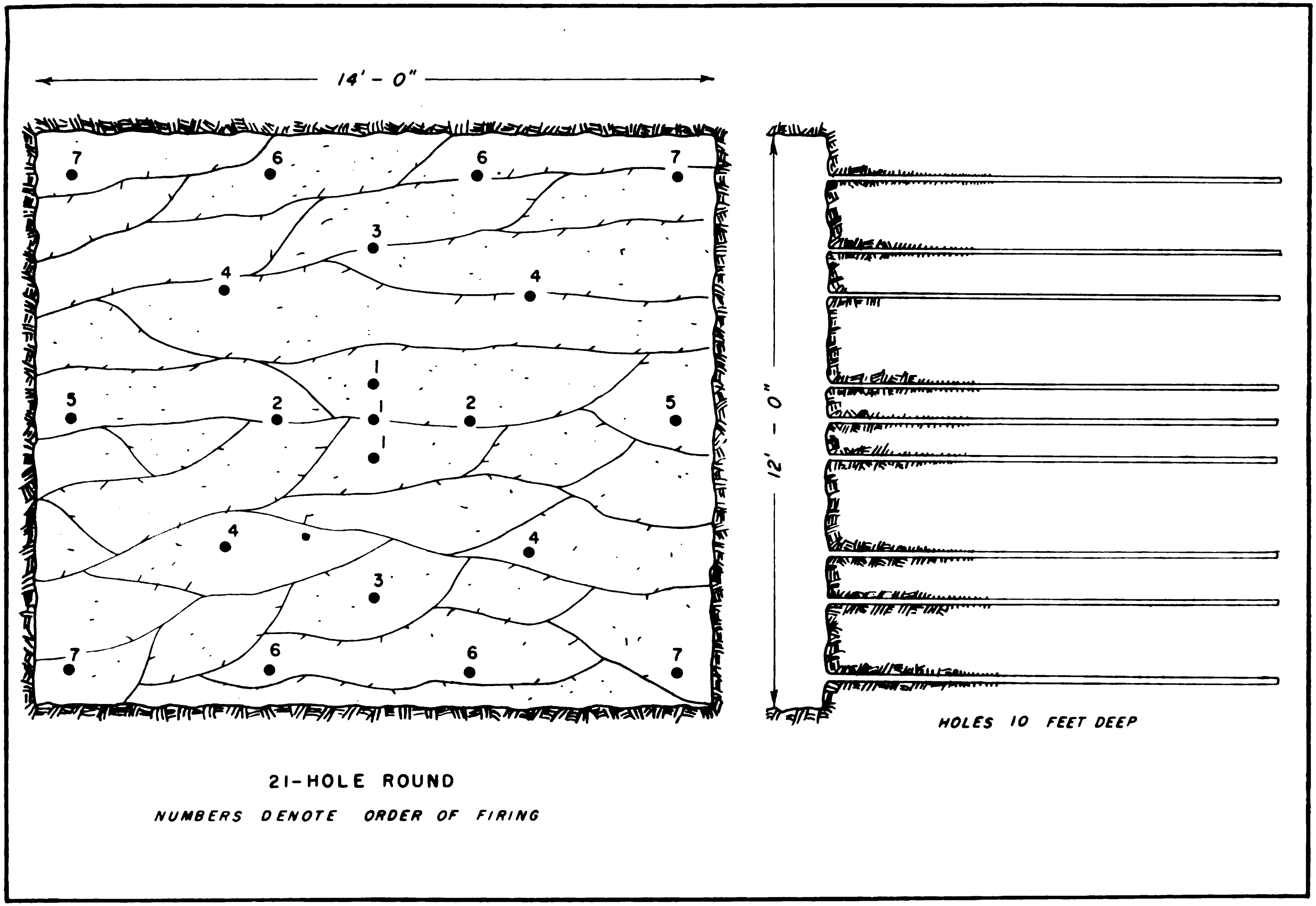

Figure 3. - Plan and profile of haulage drift round.

Drills were mounted on posts and arms in the headings and on tripods for drilling stope holes and splitters.

Present Mining

Most of the ore produced at the Westside mine in 1954 was mined from beds that overlie the original mine roof. This ore, which was submarginal in grade when the main ore body was mined, is 40 to 50 feet thick in places. Development of crawler jumbos with telescoping masts has permitted cheap and profitable mining of these upper ore beds. Telescoping masts that can be extended to a height of 70 feet are used on the jumbos in the highest stopes (fig. 4).

The high-mast jumbos are well balanced and require no outriggers or guylines for support. Elimination of the need for such support is an important safety factor, as sudden jars or breaking of a guyline by falling slabs or passing trucks could endanger the life of a miner by dislodging him from the drilling platform.

The use of crawler jumbos permits drilling and blasting high faces of ore in one operation. In the higher stopes, where the jumbos cannot be extended to reach the top of the ore, the lower part is drilled and blasted first; then the jumbo climbs the pile of broken ore, and the rest of the face is drilled. The top of the muck pile is leveled by bulldozer to provide a bearing for the jumbos (figs. 4, 5, and 6). The cycle of drilling and blasting is continued to the upper limit of the ore before any of the broken ore is loaded and transported to the hoisting shaft.

In sections of the mine where stope heights are not so great, shorter masts are used on the jumbos. Telescoping masts with a maximum length of 35 feet are used in these sections to mine the roof ore (fig. 6). Mining progresses upward in the same manner as in the high stopes. One-piece masts 12 and 20 feet long are used in the headings.

A "hi-jumbo" drilling crew consists of two men, a driller and a helper. The helper manipulates the jumbo and mast and handles drill steel and explosives.

Blast holes are drilled 17 to 20 feet deep and spaced about 6 feet apart. Four to six holes are usually drilled each shift but are not blasted until the complete round (up to 15 holes) has been drilled. Thus, the rounds are shot every second or third day, and each blast breaks 500 to 700 tons of ore. The explosives charge consists of 1 stick of 40-percent explosive per foot of hole. The holes are usually loaded when drilled; this practice saves time and expense in moving the jumbo.

Drill machines are 3-1/2- and 4-inch drifters and are operated at an air pressure of 85 to 90 pounds at the drill. Only one drill machine is used on a hi-jumbo. Drill steel now in use is 1-1/4-inch hollow round, L.C. (low-carbon) drill steel. Experience has demonstrated that breakage of this type of steel is lower than that of conventional carbon steel. Chrome-Moly alloy steel is being tested at the Westside and one other mine. Detachable, 2-5/8-inch, 4-wing, steel bits are used to drill the ore.

Drill steel is fabricated and reconditioned in a modern, central shop. Close temperature control is maintained in a gas-fired furnace to assure proper heat treatment of shanks and threaded ends. A surplus supply of drill steel is stocked at the mine to insure against undue delays in the event of excessive steel breakage underground.

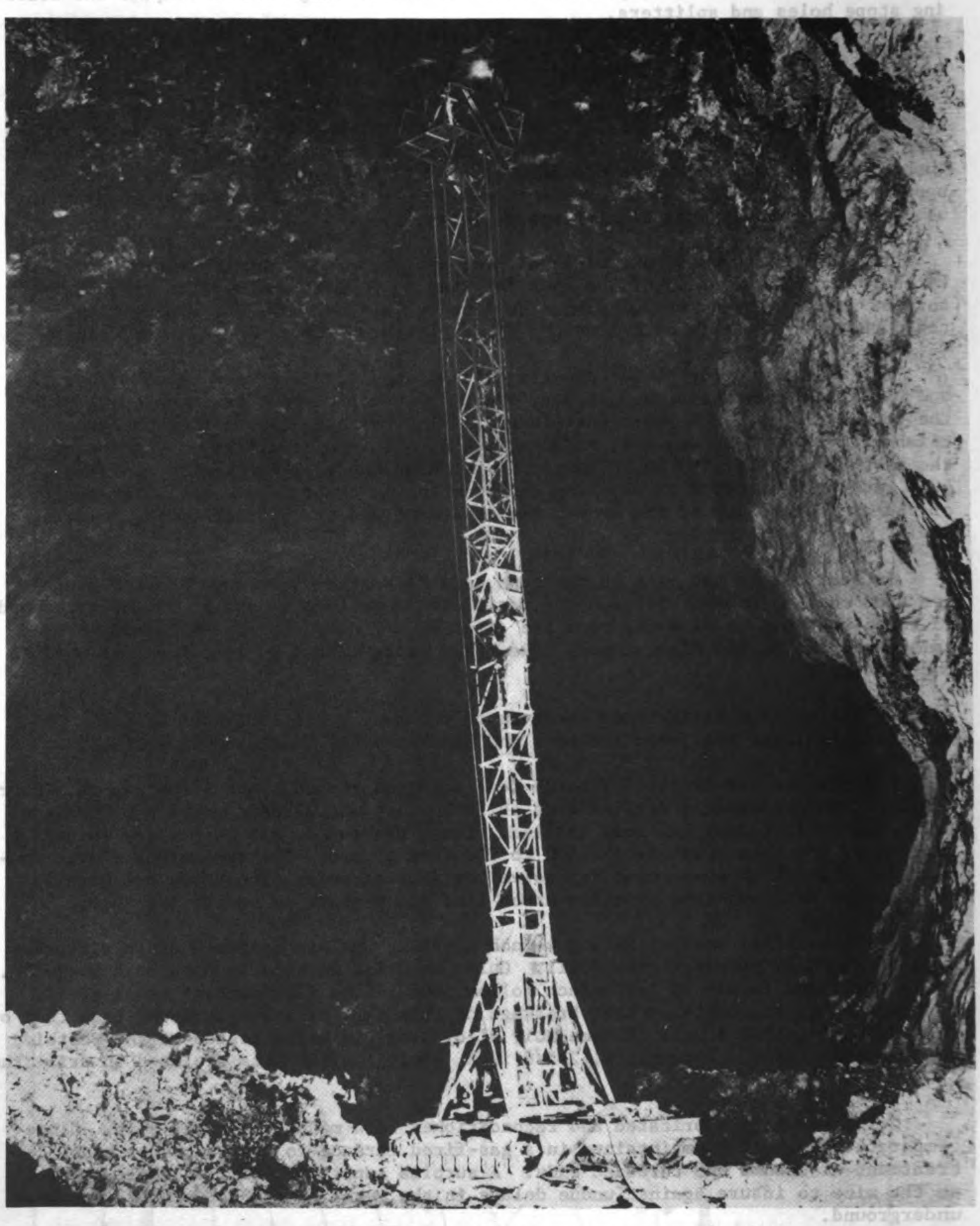

Figure 4. - Jumbo with 70-foot mast. *(Courtesy, The Eagle-Picher Co.)*

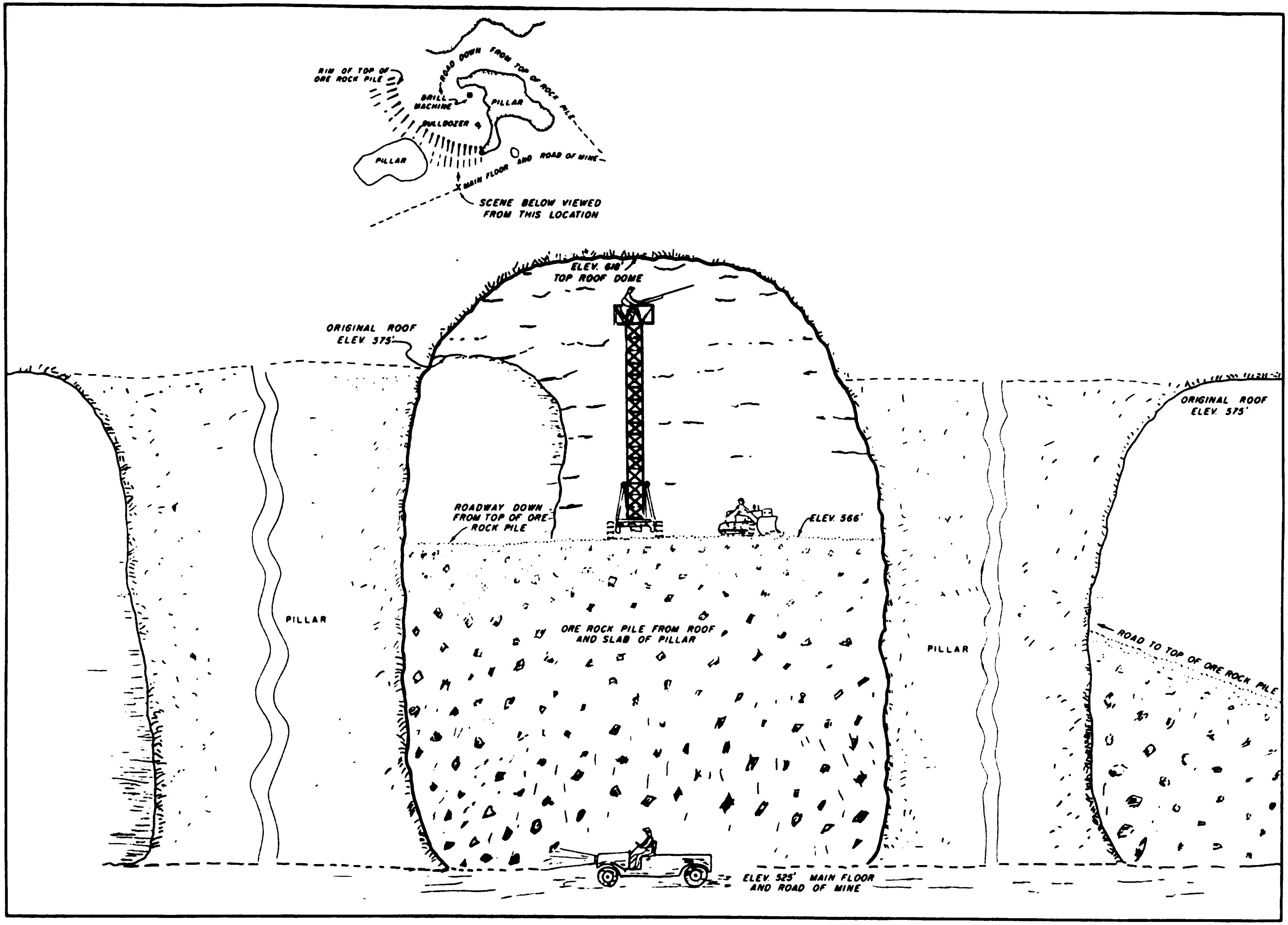
RIM OF TOP OF ORE ROCK PILE
ROAD DOWN FROM TOP OF ROCK PILE
DRILL MACHINE
PILLAR
BULLDOZER
PILLAR
MAIN FLOOR AND ROAD OF MINE
SCENE BELOW VIEWED FROM THIS LOCATION
ELEV. 618' TOP ROOF DOME
ORIGINAL ROOF ELEV. 575'
ORIGINAL ROOF ELEV. 575'
ROADWAY DOWN FROM TOP OF ORE ROCK PILE
ELEV. 566'
PILLAR
ORE ROCK PILE FROM ROOF AND SLAB OF PILLAR
PILLAR
ROAD TO TOP OF ORE ROCK PILE
ELEV. 525' MAIN FLOOR AND ROAD OF MINE

Figure 5. - A mining view in Westside mine.

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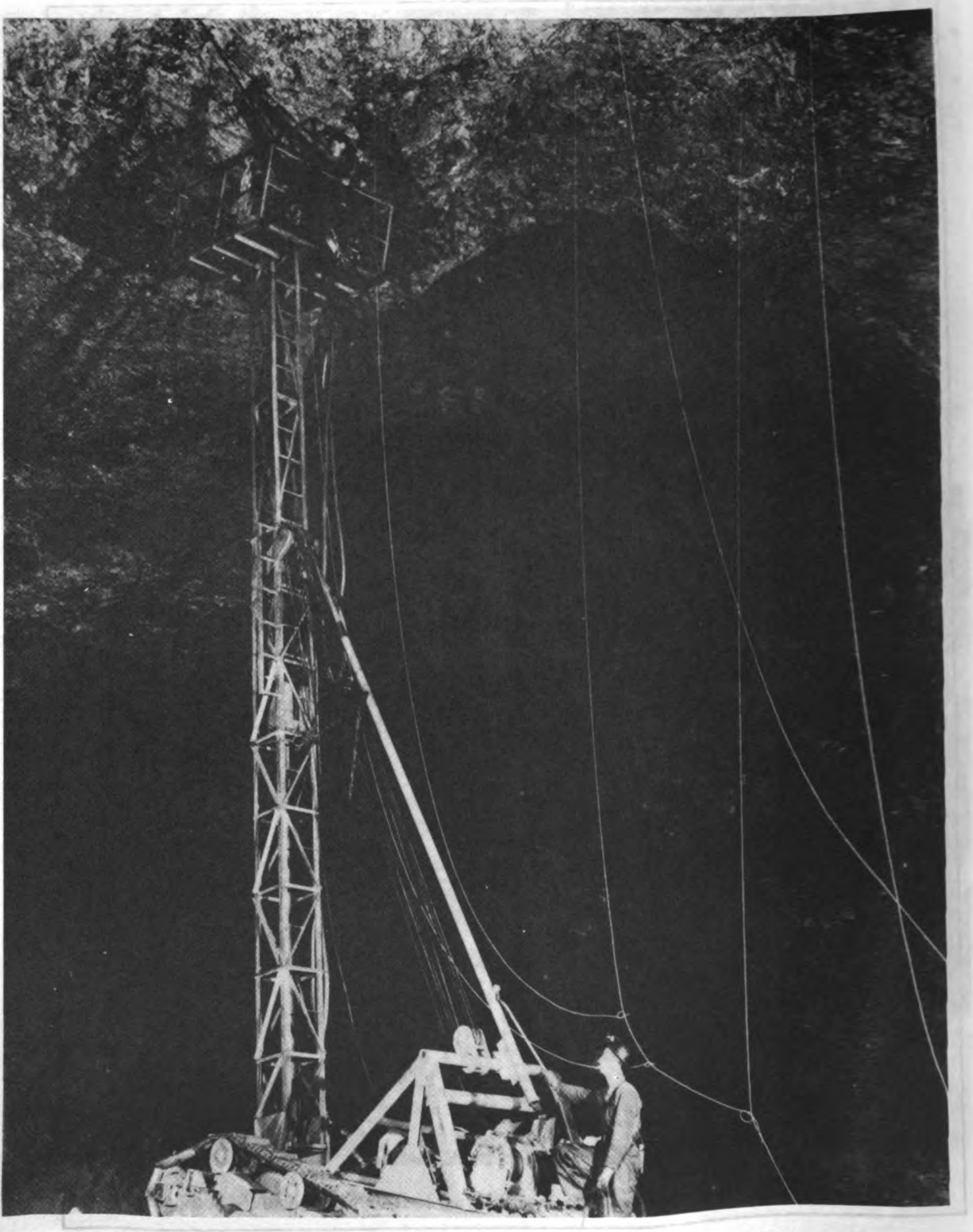

Figure 6. - Jumbo with 35-foot mast. *(Courtesy, The Eagle-Picher Co.)*

LOADING

Nearly 96 percent of the ore produced at the Westside mine in 1954 was loaded underground by diesel-powered machines. Several types and makes of loaders were used; operating conditions largely determined the selection of working places and the tonnage of ore loaded by each machine. The types of loaders used and tonnages of ore loaded by each during the year are shown in the following table.

TABLE 1. - Data on mechanical loaders

Type of loader	Shifts operated	Total tons loaded	Average tons per shift	Highest tonnage loaded (1 shift)
Thew-Lorain skimmer scoop	298	136,292	457	1,320
HT-4 front-end loader	227	33,390	147	1,270
P & H dipper-stick shovel (3/4-yard)	160	45,060	281	582
Slusher-portable drag		9,666		
Miscellaneous (mainly Eimco)		17,208		

The Thew-Lorain (fig. 7) was used mainly for loading from the large ore piles. Owing to more advantageous loading conditions, its operating costs were below the average for all loading machines. The HT-4 was used a few hours each day for leveling the broken ore at the tops of the large muck piles. This work, on highly abrasive chert and jasperoid, resulted in high maintenance costs, especially on pads and rail assemblies. The P & H shovel required a major overhaul which raised its operating cost in 1954 about $0.018 per ton above normal.

Loading costs during 1954, for all machines, are shown in detail below:

	Cost per ton
Operating	
Fuel and lubrication	$.006
Operating labor	.055
Maintenance labor	.021
Supervision	.017
Repairs and supplies	.097
Pads	.019
	.215
Undistributed	
Shop labor	.035
Miscellaneous repairs and supplies	.024
	.059
Total	$.274

UNDERGROUND TRANSPORTATION

Ore was transported underground in 1954 by 10-ton semitrailer trucks (fig. 8). The tractors are custom-built by Dart and are powered by HB-400 Cummins diesel engines. Four trucks were usually operated each shift and one was held in reserve. Transportation routes from mining areas to the hoisting shaft consist of specially constructed, well-maintained truck roads (fig. 9). Rooms in the Westside mine are wide enough (30 to 40 feet) to permit the trucks to maneuver freely.

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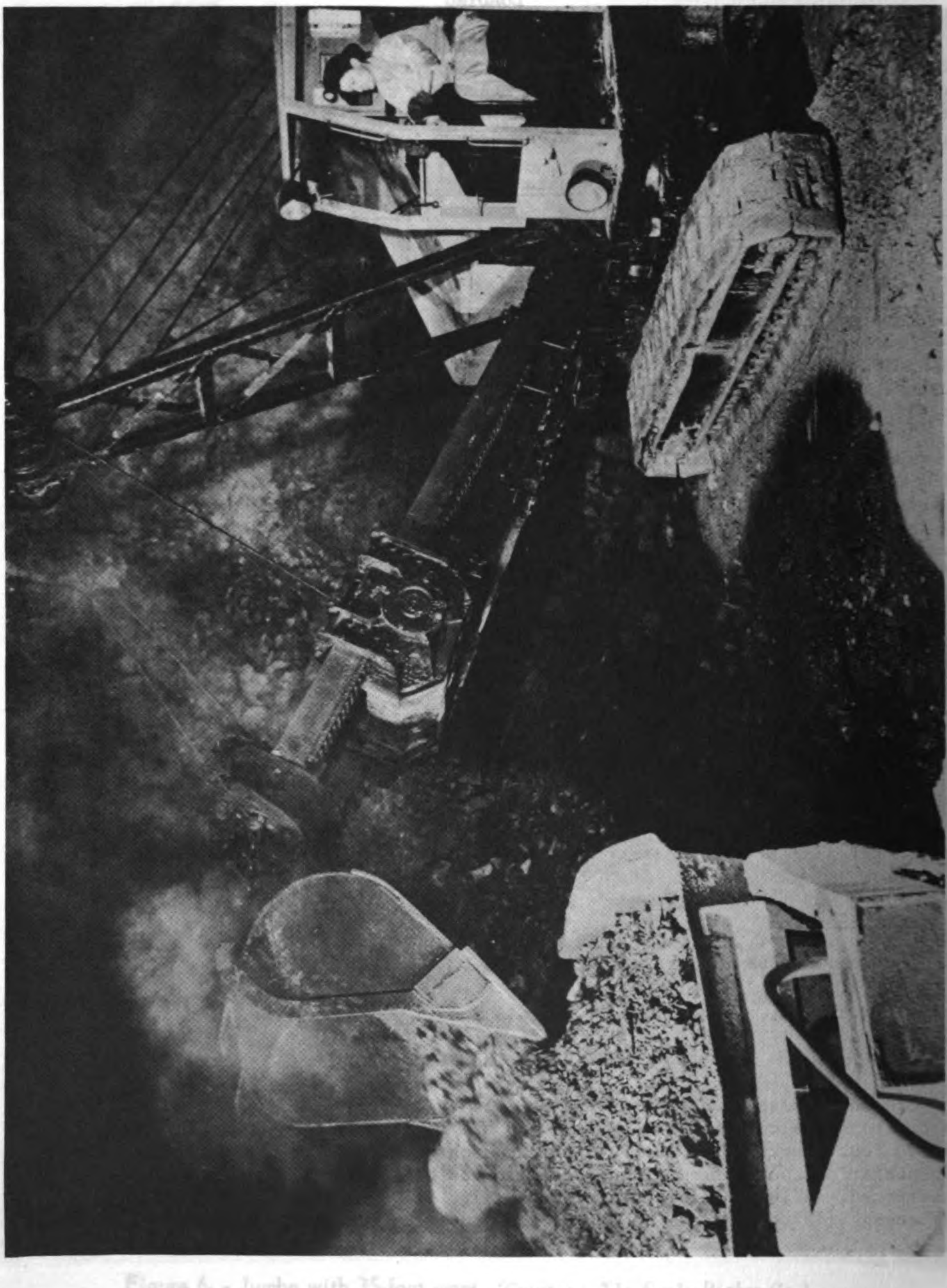

Figure 7. - Thew-Lorain loader. *(Courtesy, The Eagle-Picher Co.)*

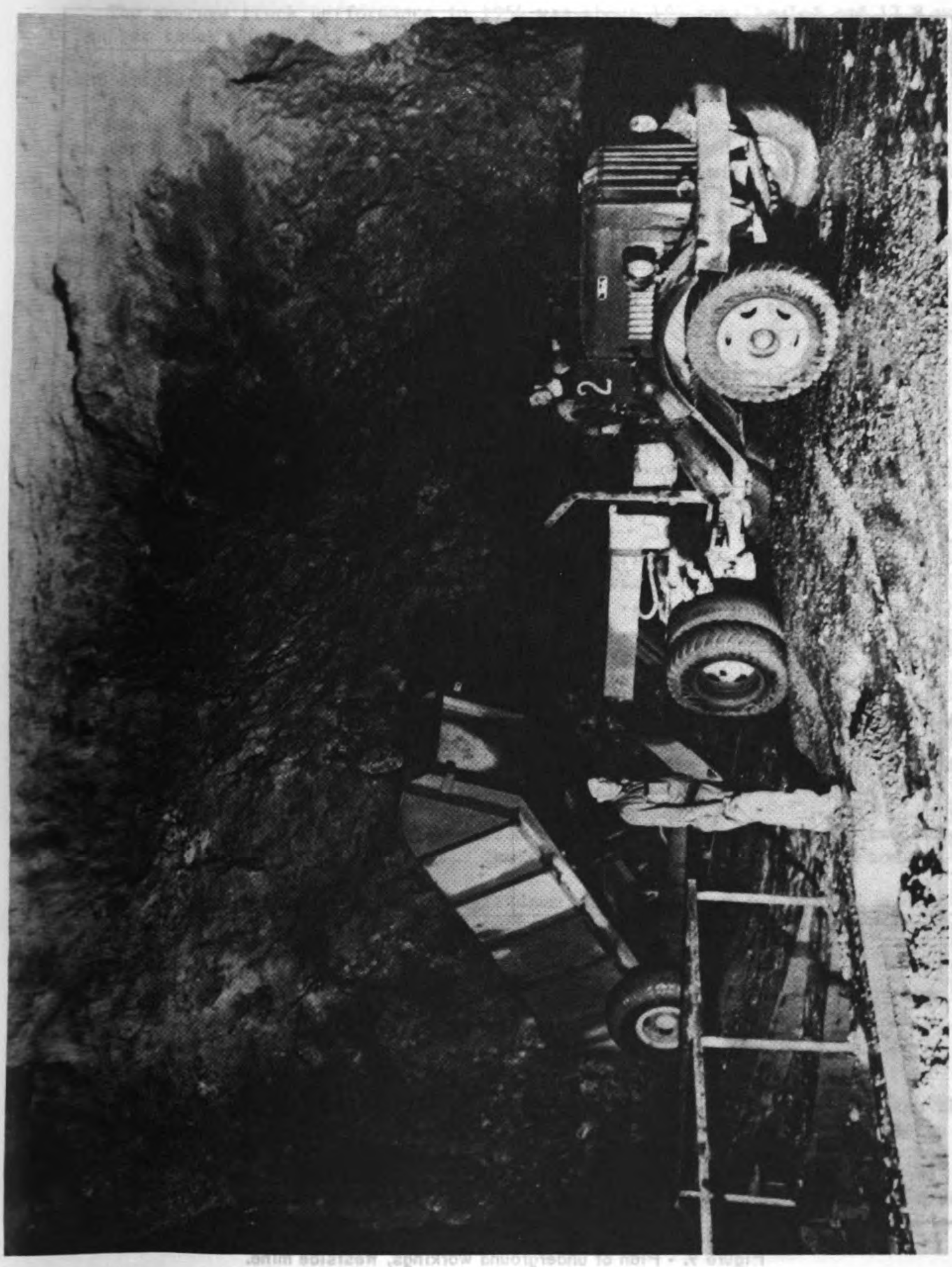

Figure 8. - Ten-ton, diesel-powered ore truck. *(Courtesy, The Eagle-Picher Co.)*

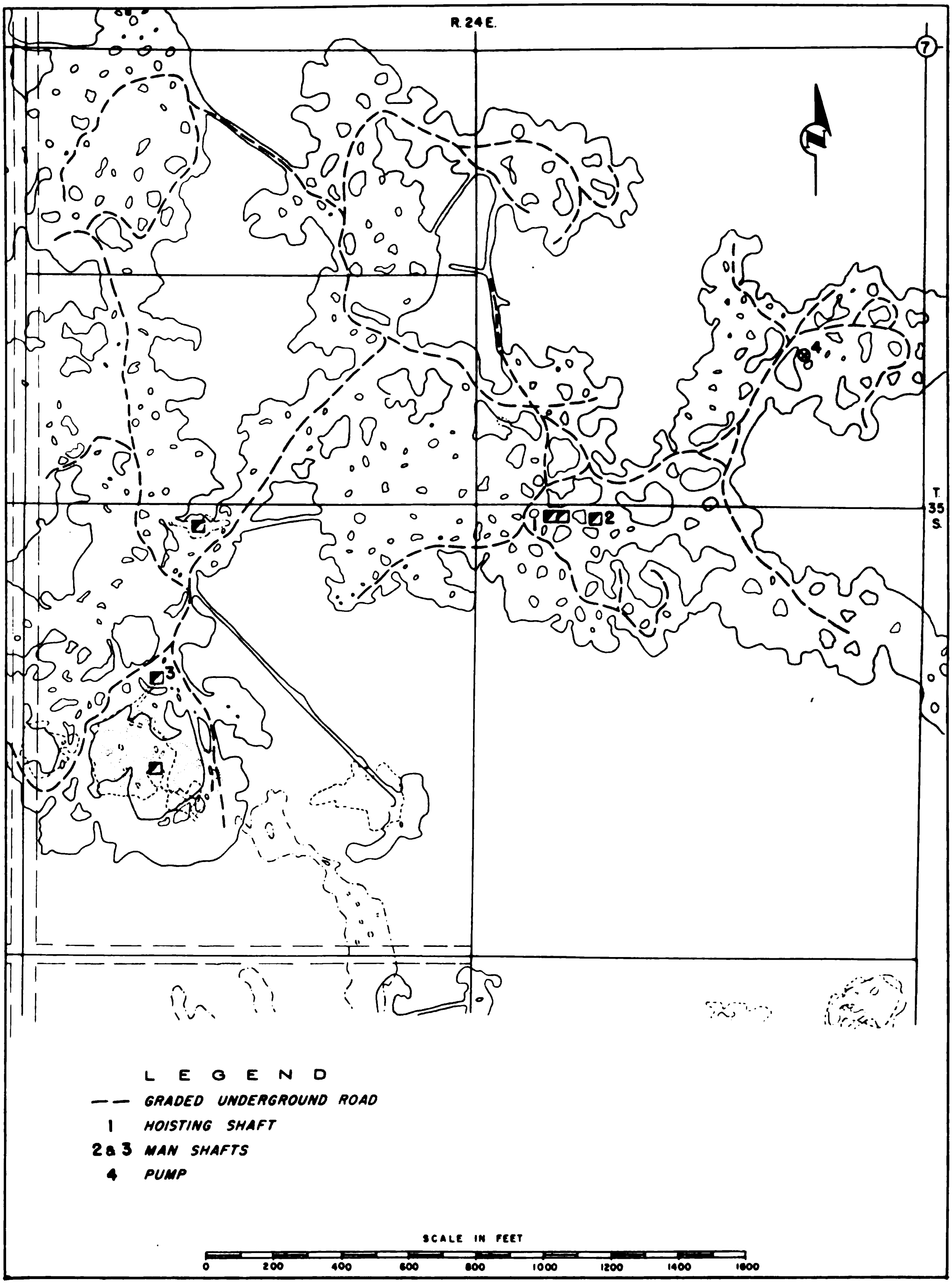

Figure 9. - Plan of underground workings, Westside mine.

The average truck performance in 1954 was about 193 tons hauled and 17.8 round trips per truck per shift. Ore was transported from 5 mining areas; the shortest haul to the hoisting shaft was 500 feet and the longest was 2,700 feet. The average round trip distance was 2,660 feet.

Records show that unit tire and repair costs are slightly less for semitrailers than for dump-bed trucks. Since truck haulage was initiated in Tri-State mines of The Eagle-Picher Co., dump-bed trucks have hauled about 6 million tons of ore at a repair cost of $0.031 per ton, and semitrailer trucks have hauled about 4 million tons at a repair cost of $0.028 per ton. The tire cost at the Westside mine in 1954 was $0.024 per ton of ore hauled, whereas the average tire cost for all dump-bed trucks operated in the company's Tri-State mines was $0.034 per ton.

The average unit costs of transporting ore underground at the Westside mine in 1954 were as follows:

Unit	Cost per ton
Operating labor	$.052
Maintenance labor	.006
Tires	.024
Repairs	.028
Fuel and lubricants	.006
	.116
Supervision	.017
Undistributed shop expense	.029
Miscellaneous repairs and supplies	.036
Total	$.198

HOISTING

All ore mined in the Westside mine is hoisted through a 2-compartment shaft, 417 feet deep (fig. 9). The ore is hoisted in 2-ton skips and is dumped into a 1,000-ton steel hopper built onto a 90-foot steel headframe. Ore is fed directly from the hopper into railroad cars for transportation to the Central mill.

The skips are loaded underground from a skip pocket, or hopper, by two skip loaders who operate the chute gates. The skip pocket holds about 1,000 tons.

The hoist is equipped with a single drum and plain gear and pinion, and is powered by a 100-horsepower, 25-cycle motor. The hoisting cable is 1-1/8-inch, 6 by 19, and moves about 250,000 tons before being replaced.

The expected output of this hoisting shaft is 400 skips per shift and the average is close to that figure.

VENTILATION

The mine workings are ventilated to some extent by natural draft through the several shafts, but forced draft in the working areas is required to provide an adequate continuous supply of fresh air. The requisite ventilation is effected by the use of blowers installed at the surface over churn-drill holes that are connected with the mine workings. The blowers are driven by 5-horsepower electric motors.

MINE DRAINAGE

Drainage has ceased to be a major problem in nearly all the mines of the Oklahoma-Kansas field. Forty years of pumping has lowered the water table about 200 feet.

The current rate of pumping at the Westside mine is 500 gallons of water per minute. In past years the rate was as high as 1,500 gallons per minute. The mine is drained by a turbine-type pump which is installed in the eastern, or deepest, part of the mine (fig. 9). The pump is operated 24 hours a day. A large sump about 20 feet deep was excavated to provide temporary storage of water as protection for the pump in case of power failure.

The pump contains seventeen 10-inch bowl assemblies, has a 1-13/16-inch water-lubricated shaft with belted head, and is driven by a 75-hp., 2,200-volt, 25-cycle, 725-r.p.m. motor. The pump speed is 1,560 r.p.m. A small, steel headframe erected over the pump permits quick changes of bowl assemblies.

Water is pumped through an 8-inch line to the man-shaft (fig. 9), a distance of about 900 feet. The shaft is 398 feet deep.

WAGE AND BONUS SYSTEM

Wages paid to the mine crew are based primarily on established hourly rates. In addition to the set wage, each man on production participates in a bonus system which is based on unit ore production that exceeds a certain predetermined standard. The production standard, in terms of tons of ore produced per man per shift, is determined from past experience and is subject to periodic revision, either up or down, as operating or physical conditions warrant. Each participant receives a bonus of $1.25 for each ton of ore produced per man per shift (weekly average) in excess of the standard or base rate. The base at the Westside mine is 16 tons per man per shift. The average bonus earned by each man is about 26 cents an hour.

Machinemen and helpers, when employed in development work - in drifts, raises, or on road construction - do not share in the production bonus. Their hourly rates are adjusted, however, to compensate for nonparticipation. The makeup of the mine crew in 1954 and the individual wage rates are shown below.

Classification	Number	Hourly wage rate
Foreman	1	Salary
Shovel boss	1	$1.75
Machineman	4	1.40
Hi-Jumbo machineman	2	1.65
Hi-Jumbo machine helper	2	1.58
Powderman	1	1.40
Roof trimmer	1	1.43
Truck driver	[1]3	1.37
Sprinkler	1	1.24
Welder	1	1.42
Maintenance man	1	1.40
Hoistman	2	1.48
Skip loader	2	1.36
Screenman	2	1.27
Traction-drag operator	1	1.40
Diesel-loader operator	4	1.43

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[1] The fourth truck is driven by a man whose duties are divided, as needed, between loading and transporting ore.

The equivalent hourly rates for machinemen and helpers, when working on development, were $1.65 and $1.58, respectively. The hourly rates listed above were based on a 40-hour week. Actual rates paid for working the full 48-hour week were 52/48 of the quoted rates.

SAFETY

The company maintains a safety organization which consists of a chief safety inspector and two traveling inspectors. Regular and systematic examinations are made of all workings and equipment, and the inspectors are authorized to stop all unsafe operations. The Westside mine has a favorable safety record, showing few and infrequent lost-time accidents each year.

STATISTICAL DATA

In 1954 the Westside mine was operated six 8-hour shifts a week for a total of 312 shifts. The total output of ore was 241,616 dry short tons and the daily average 774 tons. Unit output was 208.3 tons of ore per drill shift and 21.97 tons per man per shift.

Electric power is used for hoisting, pumping, lights, ventilating, and shops. Total power consumption was 908,240 kw.-hr. Compressed air is supplied from two central compressor plants which serve all the mines in the central part of the field through an interconnected system.

Bit and Drill-Steel Data

Statistical and cost data on the performance of bit and drill steel are shown in table 2.

TABLE 2. - Bit and drill-steel data

Item	Total number	Number per drill shift	Tons broken	Feet drilled	Pounds per rock ton	Cost per drill shift	Cost per ton	Cost per foot drilled
Drill shifts	1,160							
Holes drilled	5,485	4.7						
Feet drilled	72,131	62.2						
Per foot drilled			3.35					
New steel bits	4,350	3.8						
Resharpened bits	1,825	1.6						
Carbide bits (test)	79							
Average depth of hole ...				13.2				
Per total bit			38.6	11.5				
Holes per new bit	1.2							
Pieces of steel broken ..	343	.3						
Per break				210.3				
Drill-steel consumption:								
Average all steel					0.0758			
Chrome-molybdenum					.0322			
Drill-bit costs						$3.64	$0.0174	$0.0585
Drill-steel costs						2.55	.0122	.0410

TABLE 3. - Summary of costs

Name of mine Westside Period covered Year 1954
Tons of ore hoisted during period 241,616 Mining method Open stopes with pillar support

1. Underground costs per ton of ore hoisted:

	1. Labor[1/]	2. Super-vision[2/]	3. Compressed-air drills and steel	4. Power	5. Explo-sives	6. Other supplies	7. Total
Development	-	-	-	-	-	-	-
Mining	$0.543		$0.078	$0.006	$0.134	$0.073	$0.834
Transportation (underground)	.123					.075	.198
General underground expense	.061			.006		.066	.133
Surface expense (directly applicable to underground operation).	.070			.006		.028	.104
Total	$.797		.078	.018	.134	.242	1.269

[1/] Includes 7.5 percent of direct labor costs for social security, compensation insurance, and unemployment benefits.

[2/] Included under labor.

TABLE 4. - Summary of costs in units of labor, power, and supplies

Name of mine Westside Period covered Year 1954
Tons of ore mined and hoisted 241,616 Mining method Open stopes with pillar support

	Mining
A. Labor (man-hours per ton)	
Breaking (drilling, blasting, trimming)	0.124
Loading	.062
Haulage and hoisting	.082
Supervision	.021
General	.075
Total labor	.364
Average tons per man-shift (underground)	24.91
Average tons per man-shift (surface)	193.6
Average tons per man-shift (total)	21.97
Labor, percent of total cost	62.8
B. Power and supplies	
Explosives (40-percent strength)(pound per ton)	.4435
Total power (kw.-hr. per ton)	3.76
(1) Air compression - 1.25	
(2) Hoisting ...... - 1.26	
(3) Pumping .... - .94	
(4) Ventilation) Lighting)... - .31	
Other supplies in percent of total supplies and power	51.3
Supplies and power (percent of total cost)	37.2